

## PATENT COOPERATION TREATY

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## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 03 01 731 285	<b>FOR FURTHER ACTION</b> <span style="float: right;">See Form PCT/PEA/416</span>	
International application No. PCT/DK2004/000735	International filing date (day/month/year) 26.10.2004	Priority date (day/month/year) 27.10.2003
International Patent Classification (IPC) or national classification and IPC INV. F28F3/12		
Applicant DANFOSS SILICON POWER GMBH et al		
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> sent to the applicant and to the International Bureau) a total of 6 sheets, as follows:</p> <p style="margin-left: 20px;"><input type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p style="margin-left: 20px;"><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p>b. <input type="checkbox"/> (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>		
<p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the report</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p>		
Date of submission of the demand  18.08.2005	Date of completion of this report  03.04.2006	
Name and mailing address of the international preliminary examining authority:   European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized officer  Mootz, F  Telephone No. +31 70 340-4263 	

# INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.  
PCT/DK2004/000735

## Box No. 1 Basis of the report

1. <sup>c</sup> With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
  - ☐ publication of the international application (under Rule 12.4)
  - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements\*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

### Description, Pages

1-8, 11, 13-15  
2a, 9, 10, 12

as originally filed  
received on 27.02.2006 with letter of 27.02.2006

### Claims, Numbers

1-16

received on 27.02.2006 with letter of 27.02.2006

### Drawings, Sheets

1/8-8/8

as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):

\* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/DK2004/000735

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**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

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**1. Statement**

Novelty (N)	Yes: Claims	1-16
	No: Claims	
Inventive step (IS)	Yes: Claims	1-16
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-16
	No: Claims	

**2. Citations and explanations (Rule 70.7):**

**see separate sheet**

**1) Article 6 PCT**

The application does not meet the requirements of Article 6 PCT, because claim 1 is not clear. The passage of claim 1 reading "and wherein the plurality of the flow cells... are arranged in parallel in two directions between the manifolds" is vague and ambiguous as it allows several possible interpretations when trying to establish the scope of protection. For the purpose of assessing novelty and inventive step, this Authority has interpreted the claim as the embodiment of the distributor shown in figures 9 and 10 of the present application. It is understood that the entrance into the regional phase requires the clarification of this ambiguity by including more specific technical features of the embodiment to which the claim seems to refer.

**2) Article 33(1) PCT**

Under the provision of point 1) of the present communication, it is considered that the subject-matter of claim 1 appears to meet the criteria mentioned in Article 33(1) PCT, i.e. appears to be novel and inventive in light of the documents cited in the International Search Report.

**2.1) Article 33(2) PCT**

None of the documents cited in the International Search Report discloses the combined technical features of claim 1. The subject-matter of claim 1 is therefore novel.

**2.2) Article 33(3) PCT**

Document D1 discloses a distributor for distributing a flow, which differs from the subject-matter of claim 1 in that the housing is not manufactured in a single piece. Although the flow cells seem to be arranged in parallel in two directions, as claimed, the housing which comprises an inner wall structure defining the inlet manifold, the outlet manifold and the plurality of flow cells therein is manufactured of this known distributor is not manufactured in a single piece.

Starting from this prior art the problem to be solved by the present invention may be construed as providing a flow distributing unit which is more cost effective to manufacture without losing the possibility of providing tailored cooling for the surface(s) to be cooled.

According to the present invention this problem is solved by modifying the housing, the manifolds and the flow cells in a manner which allows them to be formed in a single piece. The corresponding solution is suggested by the embodiment shown in figures 9 and 10 and cannot be reproduced without undue burden by the housing shown in document D1 which is unsuitable for manufacturing in one single piece. Nor would the skilled man resort to the teachings described in documents D2 - D6 as they do not provide a solution for manufacturing the housing in a single piece. The subject-matter of claim 1 does therefore involve an inventive step.

2.3) Claims 2 - 16 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

**2.4) Article 33(4) PCT**

The subject-matter of claims 1 - 16 is deemed to be industrially applicable, as required by Article 33(4) PCT.

3) The attention of the applicant is furthermore drawn to the following deficiencies:

3.1) Independent claim 1 is not in the two-part form in accordance with Rule 6.3(b) PCT.

3.2) The claims contain references to the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

**Additional page 2A**

DE 202 08 106 U1 discloses a cooling device, in particular for liquid cooling of semiconductor devices. The cooling device comprises a housing and a separate baffle positioned inside the housing and with a plurality of flow cells defined therein. The flow cells each form a fluid connection between an inlet manifold and an outlet manifold. DE 202 08 106 U1 does not disclose that the housing, the manifolds and the flow cells are formed in a single piece.

US 6,101,715 discloses a microcooling device with a channel structure through which a coolant fluid can flow. The device shown in Fig. 1 comprises an inlet manifold, an outlet manifold and a plurality of flow channels manufactured in a single piece.

The flow channels are connected in parallel between the manifolds along one direction, i.e. the direction transversal to the flow direction. However, they are not arranged in parallel along any other direction. As a consequence, a temperature gradient would inevitably occur along the flow direction of the flow channels, and it would not be possible to tailor the cooling.

EP 0 447 835 concerning a cold plate and an integrated cooling module embodying a cross-hatch flow distribution scheme discloses a prior art cooling module in Figure 3. This prior art cooling module comprises an inlet and an outlet, and a meandering flow channel establishing a fluid connection between the inlet and the outlet. The flow channel is provided with fins in order to create turbulence in the cooling fluid. Since there is only one flow channel, the cooling is serial, and a temperature gradient will therefore occur.

frequency converter or motor drive, or a central processing unit (CPU). In case of a large power module it is important to eliminate, or at least considerably reduce, temperature gradients across the module. Especially if several individual power semiconductors are operated in parallel it is crucial to maintain substantially the same temperature for all components in order to reduce or eliminate the risk of thermal runaway.

The present invention also relates to a fluid-coolable electronic unit, the unit comprising an electronic circuit encapsulated in a circuit module having an outer surface, and a distributor as described above for distributing a flow of cooling fluid over the surface.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in further details with reference to the accompanying drawings in which:

Fig. 1 shows an exploded view of a prior art cooling unit,

Fig. 2 shows a perspective top view of a prior art flow distributing baffle,

Fig. 3 shows a top view of the prior art distributing baffle,

Fig. 4 shows a perspective bottom view of the prior art distributing baffle,

Fig. 5 shows an exploded top view of a prior art clamp-on cooling unit,

Fig. 6 shows an exploded bottom view of a prior art clamp-on cooling unit,

Fig. 7 shows a perspective bottom view of a flow distributing baffle in the prior art clamp-on cooling unit,

## **Replacement page 10**

Fig. 8 shows a perspective top view of the distributing baffle in the prior art clamp-on cooling unit,

Fig. 9 shows an exploded view of a one-piece flow distributor for cooling purposes, shown in front of a plate to be cooled,

Fig. 10 shows a perspective back view of the one-piece flow distributor,

Fig. 11 shows an exploded view of a prior art one-piece flow distributor having two cooling plates,

Fig. 12 shows a prior art flow distributor having a circular shape and having ten plates to be cooled arranged on an inner periphery, and

Figs. 13 and 14 show exploded views of a prior art flow distributor having a cooling plate and a radiator arranged thereon.

## **DETAILED DESCRIPTION OF THE DRAWINGS**

Turning now to Fig. 1, a cooling unit 1 includes a housing 13, formed as a box with a flat back plate 11 and side walls 20 which extend from the back towards a main opening at the front of the box. The housing 13 has an inlet opening 15 and an outlet opening 14 for liquid connections from a pipe system or the like.

A baffle 4 fits with the internal surfaces of the side walls 20 of the housing 13. When the baffle 4 is placed in the housing 13, it divides this into a top compartment and a bottom compartment. The bottom compartment is formed between the back plate 11 and the baffle 4, and is further divided into two chambers or manifolds, as will be described later. The openings 14 and 15 are in fluid communication with the bottom compartments.

A top plate 3, the lower surface of which is to be cooled, closes the top compartment when it is mounted on the main opening on the housing 13, by



## Replacement page 12

- side, will bear on the bottom plate 11 of the housing 13 in substantially fluid-proof abutment. The bottom compartment of the baffle 4 is hereby divided into an inlet compartment or manifold 8 and an outlet compartment or manifold 9, when the baffle 4 is placed in the housing. All cell inlets 5 are in connection with the inlet manifold 8, and all cell outlets 6 are in connection with the outlet manifold 9. The cells of the top compartment, Figs. 2 and 3, are thus all connected in parallel between the inlet manifold 8 and the outlet manifold 9, and thus in parallel between inlet and outlet positions 15 and 14 of Fig. 1.
- 10 The inlets 5 and the outlets 6 are placed such that the outlet of one cell is next to an inlet of another cell. This has the effect that heated liquid, which is about to leave one cell, is close to unheated liquid which has just entered a neighbouring cell. This serves to minimize the heat gradient along the cooled plate 3. The heat gradient along the cooled plate is further minimized by
- 15 varying the size of the area which the cells cover. Along the edges 12 the area of each cell is larger than on the rest of the surface, whereby the cooling in the area along the edges 12 is less effective than on the rest of the area. This reflects a situation where the density of heat generating elements is lower along the edges of a semiconductor device than on the rest of the device.
- 20 Lowering the cooling effect along the edges of the cooling unit will improve temperature uniformity across the cooled plate.

- In the cooling unit shown in Figs. 1 to 4, it is intended that a substrate with semiconductors be placed on top of the cooled plate 3, in a way known to those skilled in the art. The cooled plate could however be the substrate itself,
- 25 placed directly as a cover on the cooling unit. This is a consequence of the minimized heat gradient along the cooled plate, which makes the traditional heat spreading plate, shown in Fig. 1 as the cooled plate 3, superfluous in some applications.

- Figs. 5 to 8 show several views of a similar cooling unit with dimensions
- 30 adapted for cooling a microprocessor, a video display processor or a similar

## CLAIMS

1. A distributor for distributing a flow of fluid over at least one surface to be cooled, the distributor comprising a housing being manufactured in a single piece and having formed therein an inlet manifold, an outlet manifold and a plurality of flow cells (Figure 10; 26, 27, 28, 29) connected between the manifolds,  
 5 each flow cell (Figure 10; 26, 27, 28, 29) comprising a cell inlet (Figures 9 and 10; 5) in fluid communication with the inlet manifold, a cell outlet (Figures 9 and 10; 6) in fluid communication with the outlet manifold, and a flow channel for guiding a flow of fluid from the cell inlet (Figures 9 and 10; 5) along the surface(s) to the cell outlet (Figures 9 and 10; 6),  
 10 wherein an inner wall structure of the housing defines the inlet manifold, the outlet manifold and the plurality of flow cells (Figure 10; 26, 27, 28, 29), and wherein the plurality of flow cells (Figure 10; 26, 27, 28, 29) are connected in parallel between the manifolds and are arranged in parallel in two directions between the manifolds.
- 15 2. A distributor according to claim 1, wherein each flow channel is formed to cause a plurality of changes in the direction of flow of the fluid flowing along the surface(s).
3. A distributor according to claim 1 or 2, wherein the housing comprises at least one main opening formed to be closed in a substantially fluid tight fashion by a surface to be cooled.
4. A distributor according to claim 3, wherein the housing comprises at least two main  
 20 openings, each being formed to be closed in a substantially fluid tight fashion by a surface to be cooled.
5. A distributor according to claim 4, wherein at least two of the main openings are arranged in the same plane or in substantially parallel planes.
6. A distributor according to claim 4 or 5, wherein the housing comprises two main openings  
 25 being arranged in substantially parallel planes opposite each other with the inner wall structure arranged in between.
7. A distributor according to claim 4, wherein the housing comprises at least three main openings being arranged relatively to each other in such a way that a cavity is formed between them, the inner wall structure being arranged within said cavity.

8. A distributor according to any of the preceding claims, wherein the housing comprises an inlet opening (Figure 9; 15) for leading fluid to an inner part of the housing and an outlet opening (Figure 9; 14) for leading fluid out from the inner part of the housing, the inlet opening (Figure 9; 15) being in fluid communication with the inlet manifold, and the outlet opening (Figure 9; 14) being in fluid communication with the outlet manifold.
9. A distributor according to claim 8, wherein the inlet opening (Figure 9; 15) and the outlet opening (Figure 9; 14) are formed on an outer surface of the housing.
10. A distributor according to claim 9, wherein the housing comprises a substantially plane surface (Figure 9; 11) having the inlet opening (Figure 9; 15) and the outlet opening (Figure 9; 14) formed therein, and having the inner wall structure formed on one side thereof.
11. A distributor according to any of the preceding claims, wherein the inner wall structure delimits at least one inner flow cell (Figure 10; 27, 29) for distributing fluid over a central part of the surface(s) to be cooled and at least one outer flow cell (Figure 10; 26, 28) for distributing fluid over a peripheral part of the surface(s) to be cooled.
12. A distributor according to any of the preceding claims, wherein the inner wall structure delimits a meandering flow path along the surface(s) in each flow cell (Figure 10; 26, 27, 28, 29).
13. A fluid-coolable unit for removing heat from a heat source, the unit comprising a plate heated by the heat source and a distributor according to any of the preceding claims for distributing a flow of cooling fluid over a surface of the plate.
14. A fluid-coolable unit according to claim 13, wherein the unit comprises two plates, each being heated by a heat source, and wherein the distributor is adapted to distribute a flow of cooling fluid over a surface of each of the plates.
15. The use of a unit according to claim 13 or 14 for removing heat from an electronic circuit.
16. A fluid-coolable electronic unit, the unit comprising an electronic circuit encapsulated in a circuit module having an outer surface, and a distributor according to any of claims 1-12 for distributing a flow of cooling fluid over the surface.